DESIGN OF MODERNIZED SUBWAY SYSTEM CONNECTING BOCAUE TO SM SAN JOSE DEL MONTE, BULACAN

An Experimental Research Presented to the

Faculty of Civil Engineering Division

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In Partial Fulfillment of the Requirements for the Degree

Bachelor of Science in Civil Engineering

Major in Construction Engineering

and Management

Castrence, Joana Mae B.

Dichoso, Mency L.

Evangelista, Heart Rachelle B.

Morales, Khobie Angela L.

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RECOMMENDATION

This is to certify that this research, titled "DESIGN OF MODERNIZED SUBWAY SYSTEM CONNECTING BOCAUE TO SM SAN JOSE DEL MONTE, BULACAN" prepared and submitted by Joana Mae B. Castrence, Heart Rachelle B. Evangelista, Mency L. Dichoso, Khobie Angela L. Morales, in partial fulfilment of the requirements for the degree Bachelor of Science in Civil Engineering Major in Construction Engineering and Management, is hereby recommended for Final Defense.

Engr. Eloisa P. Cadag, RCE, MACT
Research Adviser

PANEL OF EXAMINERS

Examined and approved by the Panel of Examiners in Final Defense with a grade of _____ on November___,2025, at la Concepcion College, Bulacan.

Engr. Danilo A. Casas, LPT, MAEd
Chairperson

Engr. Caroline A. Asuncion, MSCE
Member

Engr. Camilo A. Batulan Jr., MSCM
Member

Accepted and approved in partial fulfilment of the requirements for the degree Bachelor of Science in Civil Engineering Major in Construction Engineering and Management.

Engr. Jore Gil D. Galeza, MEM, Ph.D.(c)
Division Head of Civil Engineering

Dr. Leilani I. Cusack Ph.D., DBA
Dean of Instruction

CERTIFICATE OF ORIGINALITY

This certificate demonstrates the fact that the work was original to the researchers and that no other individual or group has written or published it before. Moreover, it declares that until proper acknowledgement has been given to them, no honors or recognition from other universities, colleges or higher education institutions were claimed here.

Furthermore, we claim that our study's intellectual content is the product of our hard work, which required using both simple terminology and efficient presentation methods in addition to the group's original ideas.

Castrence, Joana Mae B.

Dichoso, Mency L.

Evangelista, Heart Rachelle B.

Morales, Khobie Angela L.

Attested by:

Engr. Eloisa P. Cadag, RCE, MACT
Research Adviser

Date: _____

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CHAPTER 1

The Problem and its Background

This chapter presents the overview of the study, including the introduction, background of the study, theoretical framework, conceptual framework, statement of the problem, hypothesis, scope and limitations, significance of the study, and definition of terms.

Introduction

City growth in the Philippines, especially in the National Capital Region (NCR), has led to an increase in population density, posing significant challenges for transportation facilities. The current roadways are often congested, resulting in long commute hours. As growing municipalities like Bocaue and San Jose Del Monte City in Bulacan Province continue to expand, the need for sustainable, efficient, and commuter-friendly mass transit solutions is crucial.

The study addresses the urgent need for improved transportation between Bocaue and SM San Jose in Bulacan by designing a modernized subway system. As of today, the main transport system between the municipalities is through the roadways or by public utility vehicles (PUVs) like jeepneys and buses. Additionally, motorcycle taxis became an alternative to these traffic congestion problems. The reliance on these transportation methods contributes a lot to traffic and makes it hard for many

commuters. The subway system will provide a dedicated, high-capacity, and quality transit option that can ease the passengers. It could promote economic growth, lessen travel times, and improve the transportation experience of commuters.

Moreover, this study looks into the feasibility and design details for a subway that links Bocaue and SM San Jose Del Monte. It will cover various aspects of subway design, such as route alignment, station placement, tunnel construction techniques, and system integration. Additionally, this will explore the potential environmental and social effects of the proposed subway, incorporating sustainable design principles to reduce negative impacts and increase benefits for the community. By offering a thorough design proposal, this research aims to help develop a modern, efficient, and sustainable transportation system that meets the changing needs of Bulacan's growing population.

Background of the Study

As the municipalities of Bocaue, Santa Maria and City of San Jose Del Monte, Bulacan continue to grow, their population rates also accelerate. This population spike contributes to the increasing number of vehicles that causes traffic congestion around the city. Albeit the roadways rerouting, the travel time consumed by the commuters did not minimize.

Nowadays, the population of Bocaue is estimated to be 141 000, Santa Maria has 289 000 and San Jose Del Monte has 651 000 with 1.06 percent, 2.61 percent and 1.8 percent population growth respectively. This contributes to the traffic congestion that many of us experience in our daily travels. According to richestph.com, traffic congestion occurs when the number of vehicles trying to use a road exceeds the road's ability to handle them efficiently. Imagine trying to squeeze too much water through a narrow pipe – that's essentially what happens with traffic. This results in slower speeds, longer commute times, and frustrating gridlock. It's a common headache in many urban areas, fueled by a mix of factors like a high concentration of vehicles, inadequate roads and public transport, and sometimes, less-than-ideal traffic management.

The subway spanned for about 15-20 km across two municipalities and a city of Bulacan: Bocaue, Santa Maria, and San Jose Del Monte. The initial locations of the stations were located at the municipality of Bocaue are Ciudad de Victoria and Balutan, however on Santa Maria is on Luwasan. On the other hand, New Bypass, Muzon, Gaya-Gaya, and SM San Jose in the City of San Del Monte. These locations were chosen according to the accessibility, population density, existing and future transport demands, major road corridors, land use (commercial, industrial, and residential), and local transport routes.

Scope and Limitation

The scope of this research focuses on the subway system that has undergone modernization modifications on the system itself, the route it passes, and the location of its stations. This aims to discuss how a modernized subway could help in mitigation of the traffic congestion, long commute hours, environmental pollution and travel stress.

This study is limited to the subway system, the design of stations and routes along Bocaue, Santa Maria and San Jose del Monte and the passengers.

Theoretical Framework

Modernization Theory, as outlined by economist Walt Rostow in his 1960 book *The Stages of Economic Growth: A Non-Communist Manifesto*, which explains economic and social development as a progressive process through distinct stages of growth. Rostow identified five stages of growth: (1) traditional society, (2) preconditions for take-off, (3) take-off, (4) drive to maturity, and (5) age of high mass consumption. According to this theory, societies transform from traditional to modern systems by adopting technological innovations, industrialization, and improved infrastructure.

In the context of this study, Modernization Theory provides a foundation for understanding how the development of modern infrastructure, such as a modernized

subway system, contributes to societal progress and economic growth. The construction of efficient transportation systems can be viewed as part of the "take-off" and "drive to maturity" stages, where technological advancement and urbanization promote modernization.

By applying Rostow's framework, the study emphasizes that transport modernization including enhanced connectivity, reduced travel time, and improved mobility serves as a key driver in achieving sustained economic and social development. Thus, the Modernization Theory supports the idea that modern transportation projects are essential indicators of a society's transition toward modernization and progress.

Conceptual Framework

Bulacan is one of the provinces in the Philippines with a large population that multiplies constantly. This population growth causes a major increase in the numbers of passengers that utilize both public and private vehicles on a daily basis. From the researchers' current experience and daily encounter in the community, traffic congestion is a major cause of this growth in national roads. In this case, having a transportation system that is fast, safe, accessible, and reduces passengers' travel time is a need in Bulacan.

A subway has become dominant in the field of urban transit due to its high speed and large capacity of passengers. It can save spaces especially in urban land in large cities due to its underground construction (Shenghan Zhou et al., 2021). Its underground tracks make it possible to avoid buildings in the city and other transportation systems that cause traffic jams and save the passengers a lot of commuting time as it can travel from 80 km/h up to 120 km/h (Fang Zhou et al., 2025). This study aims to develop a design on an accessible subway system that incorporates modernized features like equipment and facilities that will be helpful to improve the travel experience of the passengers. It aims to establish a construction of routes and stations that has construction feasibility in areas where there are substantial numbers of commuters in the municipalities of Bocaue, Sta. Maria, and San Jose Del Monte, Bulacan.

INPUT	PROCESS	OUTPUT
1. Effectiveness of the current transportation system for the passengers. a. Time of travel b. Safety c. Accessibility d. Cost effectiveness e. Convenience	1. Construct a questionnaire to assess the passengers' view on the proposed design of a modernized subway system.	1. Effects and feasibility of adapting a new transportation system is identified and proven.
2. How can the development of a modernize subway system become efficient for the convenience and accessibility of the passengers?	2. Conducting a survey in the selected municipalities of the study.	2. Developed credible plans and design for the study's development.

3. Does having a commercial space on the stations of a subway contribute to the sustainability and economic growth of the community?	3. Collecting insights and advice from the professionals in the field, to have deep knowledge and understanding of the study.	3. Determine how the study will affect the travel experience of the passengers.
4. By visiting and getting the insights of the professionals from the field of engineering, what are the recommendations to be considered to ensure the establishment of the proposed design of a modernized subway system in the areas of Bocaue, Sta. Maria, and San Jose Del Monte, Bulacan, will be feasible? a. Mapping of route b. Design c. Safety Measures Materials	4. Gathering and interpretation of data that will help the study move forward.	4. Acquired valid recommendations and ideas regarding the modernization and adaptability of a Subway System.

Table 1.0: *The Input, Process, and Output of the Conceptual Framework*

Statement of the Problem

In the vast suburban area of Bulacan, the population of commuters multiplies annually. This study aims to design alternative routes for commuters to avoid traffic congestion, especially during rush hours, and reach their destinations without interacting much on the busy roads of Bulacan.

It aims to answer the questions:

1. Effectiveness of the current transportation system for the passengers.

    1.1 Time of travel

    1.2 Safety

    1.3 Accessibility

    1.4 Cost effectiveness

    1.5 Convenience

2. How can the development of a modernize subway system become efficient for the convenience and accessibility of the passengers?

3. Does having a commercial space on the stations of a subway contribute to the sustainability and economic growth of the community?

4. By visiting and getting the insights of the professionals from the field of engineering, what are the recommendations to be considered to ensure the establishment of the proposed design of a modernized subway system in the areas of Bocaue, Sta. Maria, and San Jose Del Monte, Bulacan, will be feasible?

    4.1 Mapping of route

    4.2 Design

4.3 Safety Measures

4.4 Materials

Objectives of the Study

The objectives of this study are to design and evaluate the effectiveness of the subway system as an efficient solution for reducing traffic congestion, minimizing environmental pollution, and decreasing overall travel time. The study aims to improve the current transportation network by providing a sustainable, reliable, and convenient mode of transit that enhances mobility and supports urban development. It seeks to assess the economic, social, and environmental impacts of implementing the subway system, identify potential challenges in its development, and examine commuter perceptions and willingness to adapt this new mode of transportation., and propose strategic recommendations to ensure its successful integration into the existing urban infrastructure, ensuring that the passengers will experience the following:

Fast travel: The development of a subway system will be built underground, which can reduce the passengers' exposure on busy roads and infrastructures that may cause traffic congestion and can reduce the travel time.

Accessible: Placing stations that are near main roads and areas that have a large population of boarding and alighting commuters to accommodate a large number of passengers.

Convenient: Having commercial space to acquire passengers' necessities while waiting for their departure time.

Hypotheses

Ha: To propose a design a modernized subway system connecting Bocaue to SM San Jose Del Monte, Bulacan, will have a considerable influence on improving the transportation experience of the community.

Ho: The proposed design for a modernized subway system connecting Bocaue to SM San Jose Del Monte, Bulacan, will have no considerable influence on improving the transportation experience of the community.

Significance of the Study

The proposed paper on the design of the modern subway system addresses the frequent traffic congestion in the city and municipalities of Bocaue, Santa Maria, and San Jose Del Monte in Bulacan by constructing a new mode of transportation that could help many commuters. It mitigates traffic congestion, environment pollution, and travel time. The findings will be beneficial for the following:

Commuters or passengers. The research addresses the transportation challenges faced by commuters, contributing possible solutions to lessen traffic congestion,

reduce travel time, and improve access to education, employment, and primary services. This modernized subway system offers a more efficient, reliable, and more comfortable mode of transportation.

Community and Local Government Units. This provides insights to the people involved in developing sustainable transportation solutions for the growing municipalities of Bocaue, Santa Maria, and the City of San Jose Del Monte. Moreover, the improvement of the connectivity mediated by the subway system could enhance economic growth in the said municipalities and city. Additionally, it could serve as a model for any similar projects in other places that face the same issue.

Future Researchers. This study will serve as a reference for future and further exploration of the subway system in the Philippines. The key factors to consider in the design and implementation of the same projects. Future researchers could build upon this paper to improve the transportation system by exploring the integration of subway systems with other modes of transportation, the use of smart technologies in subway operations, and the long-term sustainability of subway infrastructure.

Definition of Terms

Accessibility is the quality of being easy to reach, use, or understand something.

Convenience is the state of being suitable to someone's needs and purpose.

Passengers are people that travel on a public or private vehicle

Safety is the condition of being protected from dangers and inconveniences. **Subway System** a railway system made underground for mass transit in urban and suburban areas. It is designed for a fast service mode of transportation and to mitigate traffic congestion.

Traffic Congestion is a road condition where the number of vehicles exceeds and occupies most of the capacity of the road and causes long travel time. This is commonly caused by accidents, road works, and insufficient infrastructure.

CHAPTER 2

Review of Related Literature and Studies

This chapter presents a review of related literature and studies, following a thorough search done by local and foreign researchers. Those included in this chapter aid familiarizing with relevant and similar information to the current study.

Foreign Literature

As stated by Yueming Wen et.al., (2020) ventilation has its dual effect on the environmental health of the commuters in the subway station. Ventilation use is to control the temperature, humidity, and air quality to ensure the comfort and health of the people within the vicinity. The subway is "the lifeline of urban development" because it connects the city regions and relieves traffic congestion. The recent research discussed the health of the passengers. Whereas, considering air ventilation and safety of the passengers should be one of the priorities when you decide to design a subway.

As for Zhang Chenchen, Lu Dongyin, Xiao Xuemei, Wang Yanhui (2022) urban rail transit is the most effective solution to traffic congestion, and it has become the main mode of urban public transportation. Thus, the continuous expansion of URT caused the energy consumption to increase a lot. Modernizing a design also means

decreasing the consumption of electricity. In our country, frequent power failures are one of the common problems of the railway system.

According to Willem Haanstra, Alberto Martinetti, Jan Braaksma, and Leo van Dongen (2020), environmental sustainability is aiming to preserve environmental assets to ensure that they can have their purpose in the future. But for the railway sector to be considered as an environmentally sustainable option, the products and services should function in a sustainable way. When designing, the development of the new transport system was intended to focus on improving the energy efficiency of vehicles and their propulsion systems. The target audience in the framework of this study is the design and production management team that is responsible for the modernization of the train since they are the ones who have an influence on the design, and they are responsible for the train's lifespan regarding its material use. Hence, we would consider a sustainable design and will use a material that can ensure the future that they can still use it.

Eliasson, J., Kopsch, F., Mandela, S., and Wilhelmsson, M. (2020) stated that accessibility is important in considering where you will place your infrastructure. It plays an essential role in determining the real estate values, whether it is residential or commercial. The reason for that is it should depend on how easily people can access it and can get there in a short period of time. Taking into consideration the location of building infrastructure plays a big role for it to be accessible and lessen the time of the commuters to use it

The study by Gu, Jiang, Zhang, and Zou (2020) stated that the major challenge in many cities around the world is traffic congestion. The reason for that is the increase in population and people owning a car. The subway is considered an effective way to reduce congestion because it can carry a large capacity of passengers in one run. The study identified the reason for the long traffic and long travel time. Also, the effect on the speed of vehicles if they start the construction of the subway.

Local Literatures

As stated in the paper of Gomez, et al, 2023, Metro Manila, the capital city of the Philippines, and its inhabitants appear to be constantly moving. The need to maintain the fast- paced lifestyle that Manila demands persists, nevertheless. The public transportation system is one of these infrastructures that is most notable for its literal inability to keep up. Currently, it has become commonplace for commuters to wait hours for their transit, assuming any is even going to be available. Many people have gotten accustomed to spending hours on the road because of traffic, so their total time spent traveling is substantially longer in addition to the wait time for their commute.

Less than 100 miles (160 km) of railroad in the Philippines are in use, and hundreds of miles more of track are idle. Although the government of this country has ambitious intentions to expand its train system, travelers currently have little use for

it. Except, for the three elevated rail systems in Manila (LRTI, LRT2, and MRT3), which are incredibly affordable, effective, and reach a sizable portion of the city's tourist attractions.

The Philippines has limited rail infrastructures; hence buses are the primary mode of regional transportation. The quality of these services varies greatly. Many people travel on outdated buses with rough seats, little leg room, and frequent crowding. Due to heavy traffic and poor roads, your trip will be quite slow regardless of the type of bus you select.

Better transportation systems, like the Mega Manila Subway, have stronger effects on the Philippine economy and urbanity as the government invests heavily in infrastructure under the Build, Build, Build program. The Mega Manila Subway, one of its ground-breaking initiatives, is now under construction and is expected to complement Makati's existing intracity subway system. It is anticipated that using the subway will make travel less stressful and allow users to save more time.

Foreign Studies

In the study made by Cui, et. al. (2024)**,** it was stated that the subway systems are urban mass transport systems, using exclusive right-of-way, mostly operating through underground tunnels, and providing frequent, reliable, and rapid transport services. There were more than 190 subway systems in operation around the globe in

2020. Some high-density cities such as London, Paris, Tokyo, and Seoul have a high level of subway ridership with public transit accounting for 25 %–50 % of commuting journeys. Many cities in developing countries view mass transit as a strategy for mitigating traffic congestion and improving urban mobility, and this has largely contributed to the acceleration of construction of subway systems in recent years. As an effective response for solving transport and other urban problems, subway development is an optimal option for many cities in the world, given their economic, social, environmental, functional and historical aspects. Subway development has been proved to increase public transport accessibility and support urban agglomeration, improve connectivity, reliability and accessibility of urban spatial structure, increase land and property prices, contribute to compact city development and sustainable cities, and positively affect public transport equality, accessibility and connectivity, public health, travel experience, and life satisfaction.

Local Studies

According to Gina Gatarin (Beating the Traffic: Civil Society Participation in Transport Reforms and Innovations in Metro Manila, Philippines, 2023), traffic is the top concern of daily urban life among Filipinos (DOTr and GIZ 2016: 1). This is particularly true in the country's capital, Metro Manila. Its roads transform into giant parking lots, called "carmageddon", especially during rush hours. With 13 million people, its fragmented transport system cannot accommodate the increasing demand

for mobility. Factors that contribute to its worsening congestion include population growth, poorly maintained rail and road infrastructure, increased private vehicle usage, limited spaces for non-motorized transport, and lack of coherent and clear transport policies and plans, In 2014, a Japan International Cooperation Agency (JICA) study estimated that traffic congestion costs Metro Manila a daily net loss of Php 2.4 billion (US$52 million) and might increase to Php 6 billion (US$130 million) if no significant measures are taken by 2030 (JICA 2014).

Synthesis of Review of Related Literature and Studies

Modernized subway system design and development demands careful considerations of its several key factors. Maintaining a healthy environment, ensuring the safety of passengers together with systemized control on temperature, air quality and humidity. Moreover, being energy efficient is one of the significant concerns for an urban rail transit is a major consumer of energy. With a proper and careful design of the modernized subway system could help to reduce energy consumption and mitigate frequent power outages. On the other hand, it should be environmentally sustainable, with it adopting to an eco-friendly material, reduces waste and promotes energy efficient systems.

In addition to it, there would be many benefits. Subways could help lessen the traffic congestion at the same time, it could carry large capacities of passengers that

could positively impact on public health, travel experience, reduce environment pollutions and public's satisfaction.

Over 190 subways are operating worldwide, with many cities view mass transit as a vital plan to mitigate traffic congestions and improve urban mobility. High-density cities like London, Paris, Tokyo, and Seoul have achieved significant subway ridership, accounting for 25-50% of commuting journeys.

Strategic placement of subway infrastructure like the stations is vital for maximizing accessibility, reducing travel time, and increasing property values. By prioritizing these factors, cities can create modern, efficient, and sustainable subway systems that benefit both residents and the environment.

CHAPTER 3

Research Methodology

This chapter is dedicated to discussing research methods and processes. Within this section, the methodology for gathering the required data and information to support the investigation is outlined. The researcher illustrates various techniques for assessing and obtaining vital research data. Furthermore, this chapter outlines the research design, sample and population, research instruments, design and equipment, data gathering procedure, ethical consideration, statistical procedures and questionnaires used to ensure the accuracy of the research process.

Research Design

For this study, the researchers used a combination of qualitative and quantitative research to gather the necessary information needed in this paper. Quantitative data would be gathered through a survey questionnaire to determine the thoughts of respondents about subways and to also gain a deeper knowledge and understanding on the traffic issues and possible mitigations.

Sample and Population

The respondents of this research are the residents in the municipalities of Bocaue, Sta. Maria, and San Jose Del Monte, Bulacan, where busy roads exist most of the time, especially during peak hours. This includes the passengers in the public utility vehicles (PUVs) stations that usually experience being stuck in the traffic that caused them to reach their destinations behind schedule. By the use of the random sampling technique, the researchers will acquire the number of respondents for this study.

Table 2.0: *Population Sample*

Respondents	Number of Respondents
Bocaue	400
Sta. Maria	400
San Jose Del Monte	400
Total	1200

Research Instrument

The researchers used questionnaires/surveys and document/ data analysis. Surveys for the data collection of views of the passengers on the current transportation

system. The data analysis was used for the existing files and papers that concern the design of the subway, its route identification, station location and passenger profiles.

Data Collection

The data collection will therefore be conducted by the researchers that requires the filling of the structure questionnaire to the passengers that usually travels along the roads of Bocaue, Santa Maria, and City of San Jose Del Monte in Bulacan. The set of questions has observations on the current transportation system and traffic congestions. Applying the random sampling technique, over 1200 participants, 400 from each municipality, travelled on the roads along Bocaue to SM San Jose Del Monte. The survey will be administered through face-to-face and google form. Moreover, it also includes both close-ended questions to facilitate quantitative data and the questions that will help to determine the productivity of the subway corresponding to efficiency, safety of passengers, traffic mitigations and sustainability for our environment.

Statistical Method

Likert Scale is the statistical method used to interpret the data from the survey form answered by the respondents.

Scale	Interpretation
5	Strongly Agree
4	Agree
3	Possible
2	Disagree
1	Strongly Disagree

Table 3.0: *5-point Likert Scale*

Put a check on where your municipality is.

- ☐ Bocaue
- ☐ Santa Maria
- ☐ San Jose Del Monte

Questions	5 (Strongly Agree)	4 (Agree)	3 (Possible)	2 (Disagree)	1 (Strongly Disagree)
1. With the use of the current transportation system in your municipality, do you arrive at your destination on time?					
2. Do the roads in your municipality experience traffic congestion and cause delays on your schedule (school or job) while travelling?					
3. Do you think the subway is a better mode of transportation because it produces fewer greenhouse gases?					
4. Do the terminals in your area have security that can ensure the safety of passengers, especially at late hours?					
5. Do the public and private transportation in your area accommodate a large number of passengers anytime?					

6. Does your municipality have a consistent schedule of departure times?					
7. Do you think riding a subway will cost less than other transportation?					
8. Is the current transportation system in your municipality economical?					
9. In the current transportation system in your municipality, does it cause you to ride multiple vehicles to reach one destination?					
10. Is it convenient to adapt smart phone integration (tracking of your train location) when travelling?					